

Case Study Analysis for the Proposed Section 316(b) Phase II Existing Facilities Rule

Case Study Analysis for the Proposed Section 316(b) Phase II Existing Facilities Rule

U.S. Environmental Protection Agency Office of Science and Technology Engineering and Analysis Division

> Washington, DC 20460 February 28, 2002

ACKNOWLEDGMENTS AND DISCLAIMER

This document was prepared by the Office of Water staff. The following contractors provided assistance and support in performing the underlying analysis supporting the conclusions detailed in this document.

Stratus Consulting Inc.
Abt Associates Inc.
Tetra Tech
Science Applications International Corporation

The Office of Water has reviewed and approved this document for publication. The Office of Science and Technology directed, managed, and reviewed the work of the contractors in preparing this document. Neither the United States Government nor any of its employees, contractors, subcontractors, or their employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for any third party's use of or the results of such use of any information, apparatus, product, or process discussed in this document, or represents that its use by such party would not infringe on privately owned rights.

Table of Contents

Chapter A1: Ecological Risk Assessment Framework

Problem Formulation

A1-1

A1-2	Analysis
A1-3	Risk Characterization
Chapter	· A2: Everything You Ever Wanted to Know about Fish
A2-1	Introduction
A2-2	Fish Diversity and Abundance
A2-3	Influence of Fish on Aquatic Systems
A2-4	Exterior Fish Anatomy
A2-5	Interior Anatomy
Chapter	· A3: Aquatic Organisms Other than Fish that are Vulnerable to CWIS
A3-1	Plankton
A3-2	Macroinvertebrates
A3-3	Sea Turtles and Other Vertebrate Species
A3-4	Conclusions
Chapter	· A4: Direct and Indirect Effects of CWIS on Birds
A4-1	Direct Effects on Birds
A4-2	Indirect Effects on Fish-Eating Birds
A4-3	Understanding the Effects of Food Reduction on Bird Populations
Chapter	· A5: Methods Used to Evaluate I&E
A5-1	Overview of Procedure for Evaluating I&E
A5-2	Source Data
A5-3	Biological Models Used to Evaluate I&E
A5-4	Uncertainty
Chapter	• A6: Fish Population Modeling and the § 316(b) Benefits Case Studies
A6-1	Background
A6-2	Use of Stock-Recruitment Models in Fisheries Management
A6-3	Use of Stock-Recruitment Models to Evaluate CWIS Impacts
A6-4	Uncertainty in Stock-Recruitment Models
A6-5	Precautionary Approach

Chapter	A7: Entrainment Survival
A7-1	Entrainment Mortality and Entrainment Survival
A7-2	Existing Entrainment Survival Studies
A7-3	Analysis by EPA of 13 Existing Studies
A7-4	Principles to Guide Future Studies of Entrainment Survival
A7-5	Conclusions
Chapter	A8: Characterization of CWIS Impacts by Water Body Type
A8-1	Development of a Database of I&E Rates
A8-2	CWIS Impingement and Entrainment Impacts in Rivers and Streams
A8-3	CWIS Impingement and Entrainment Impacts in Lakes and Reservoirs
A8-4	CWIS Impingement and Entrainment in the Great Lakes
A8-5	CWIS Impingement and Entrainment Impacts in Estuaries
A8-6	CWIS Impingement and Entrainment Impacts in Oceans
A8-7	Summary and Conclusions
Chapter	A9: Economic Benefit Categories and Valuation Methods
A9-1	Economic Benefit Categories Applicable to the § 316(b) Rule
A9-2	Benefit Category Taxonomies
A9-3	Direct Use Benefits
A9-4	Indirect Use Benefits
A9-5	Nonuse Benefits
A9-6	Summary of Benefits Categories
A9-7	Causality: Linking the § 316(b) Rule to Beneficial Outcomes
A9-8	Conclusions
Chapter	A10: Estimating Benefits with a Random Utility Model (RUM)
A10-1	Site Choice Model
A10-2	Trip Frequency Model
A10-3	Welfare Estimation
A10-4	Data Sources
A10-5	Limitations and Uncertainties
Chapter	A11: Habitat-Based Replacement Cost Method
A11-1	Overview of HRC Valuation of I&E Resource Losses
A11-2	Steps in the HRC
A11-3	Use of the HRC Method for § 316(b) Evaluations
Δ11-4	Strengths and Weakness of the HRC Method

Chapter	A12: Threatened & Endangered Species Analysis Methods					
A12-1	Listed Species Background					
A12-2	Framework for Identifying Listed Species Potentially at Risk of I&E					
A12-3	Identification of Species of Concern at Case Study Sites					
A12-4	Benefit Categories Applicable for Impacts on T&E Species					
A12-5	Methods Available for Estimating the Economic Value Associated with I&E of T&E Species					
A12-6	Issues in the Application of the T&E Valuation Approaches					
A12-7	Conclusions					
Appendix	: A1					
Chapter	B1: Background					
B1-1	Overview of Transition Zone Case Study Facilities					
B1-2	Environmental Setting					
B1-3	Water Withdrawals and Uses					
B1-4	Socioeconomic Characteristics					
Chapter	B2: Technical and Economic Descriptions of In Scope Facilities of the Delaware					
Estuary	Transition Zone					
B2-1	Operational Profile					
B2-2	CWIS Configuration and Water Withdrawal					
Chapter	B3: Evaluation of I&E Data					
B3-1	Transition Zone Species Vulnerable to I&E					
B3-2	Life Histories of Primary Species Impinged and Entrained					
B3-3	Salem I&E Monitoring and PSEG's Methods for Calculating Annual I&E					
B3-4	Salem's Annual Impingement					
B3-5	Salem's Annual Entrainment					
B3-6	Extrapolation of Salem's I&E Rates to Other Transition Zone Facilities					
B3-7	Salem's Current I&E					
B3-8	Cumulative Impacts: Summary of Estimated Total I&E at All Transition Zone CWIS					
Chapter	B4: Economic Value of I&E Losses Based on Benefits Transfer Techniques					
B4-1	Overview of Valuation Approach					
B4-2	Economic Value of Average Annual Recreational Fishery Losses at the Salem Facility					
B4-3	Economic Value of Average Annual Commercial Fishery Losses at the Salem Facility					
B4-4	Economic Value of Forage Fish Losses					
B4-5	Nonuse Values					
D16	Summery of Maan Annual Value of Fagnomic Losses at Salam					

B4-7	Total Economic Damages for Generating Facilities Regulated Under Phase 2
B4-8	Total Economic Damages for All Transition Zone CWIS
Chanter 1	B5: RUM Analysis
B5-1	Data Summary
B5-2	Site Choice Models
B5-3	Trip Frequency Model
B5-4	Welfare Estimates
B5-5	Limitations and Uncertainty
Chapter 1	B6: Benefits Analysis for the Delaware Estuary
B6-1	Summary Figures of Salem's Baseline Losses
B6-2	Potential Economic Benefits due to Regulation
B6-3	Summary of Omissions, Biases, and Uncertainties in the Benefits Analysis
Chapter	B7: Conclusions
Appendix	B1: Survival Factors and Other Parameters Used by PSEG to Estimate I&E Losses
at Salem	
Appendix	B2: Delaware Estuary Life History Parameter Values
Chapter (C1: Background
C1-1	Overview of Nine Ohio River Case Study Facilities
C1-2	Environmental Setting
C1-3	Water Withdrawals and Uses
C1-4	Socioeconomic Characteristics
Chantan	C2. Taskuisal & Essuamia Essilitus Nassuintiana
-	C2: Technical & Economic Facility Descriptions
C2-1	Plant Configuration
C2-2	CWIS Configuration and Water Withdrawal
Chapter (C3: Evaluation of I&E Data
C3-1	Ohio River Aquatic Species Vulnerable to I&E
C3-2	Life Histories of Primary Species Impinged and Entrained
C3-3	Facility Impingement and Entrainment Monitoring Methods
C3-4	Annual Impingement at Nine Ohio River Facilities
C3-5	Annual Entrainment at Nine Ohio River Case Study Facilities
C3-6	Methods Used to Extrapolate I&E Rates to Other Ohio River Facilities
C3-7	Annual Impingement at Nine Ohio River Case Study Facilities

C3-8	Annual Entrainment at Nine Ohio River Case Study Facilities
C3-9	Cumulative Impacts: Summary of Total Ohio River I&E
Chapter (C4: Value of Baseline I&E Losses from Selected Facilities on the Ohio River
C4-1	Overview of Valuation Approach
C4-2	Economic Value of Average Annual Losses to Recreational Fisheries Resulting from I&E at
	Nine Facilities on the Ohio River
C4-3	Economic Value of Forage Fish Losses
C4-4	Nonuse Values
C4-5	Summary of Mean Annual Economic Value of I&E at Nine Ohio River Case Study Facilities
C4-6	Extrapolation of Baseline Losses to Other Facilities on the Ohio River
Chapter (C5: RUM Analysis
C5-1	Data Summary
C5-2	Site Choice Models
C5-3	Trip Participation Model
C5-4	Welfare Estimates
C5-5	Limitations and Uncertainties
Chapter (C6: Benefits Analysis for the Ohio River
C6-1	Economic Benefits of Reduced I&E of Fishery Species At Ohio River Facilities
C6-2	Summary of Omissions, Biases, and Uncertainties in the Benefits Analysis
Chapter (C7: Conclusions
Appendix	C1: Ohio River Fish Species Life History Parameter Values
• •	C2: Species Groups for Ohio River
• •	C3: Individual Facility Results for Annual Losses and Value of I&E at Nine
• •	on the Ohio River
racilities	on the Onio River
Chapter (D1: Background
D1-1	Overview of Case Study Facilities
D1-2	Environmental Setting
D1-3	Socioeconomic Characteristics
Chapter (D2: Technical Description of Case Study Facilities
D2-1	Operational Profiles
D2-2	CWIS Configuration and Water Withdrawal

Chapter D	D3: Evaluation of I&E Data				
D3-1	Tampa Bay Aquatic Species Vulnerable to I&E				
D3-2	Life Histories of Primary Species Impinged and Entrained				
D3-3	Big Bend Impingement and Entrainment Monitoring Methods				
D3-4	Annual Impingement at Big Bend				
D3-5	Annual Entrainment at Big Bend				
D3-6	EPA's Methods for Extrapolating Big Bend's I&E Rates to Other In-Scope Facilities of Tampa Bay				
D3-7	EPA's Estimates of Big Bend's Impingement Extrapolated to Other In-Scope Facilities of Tampa Bay				
D3-8	EPA's Estimates of Big Bend's Entrainment Extrapolated to Other In-Scope Facilities of Tampa Bay				
D3-9	Cumulative Impacts: Summary of Total I&E of Tampa Bay In-Scope Facilities				
D3-10	Evaluation of Recent Larval Abundance Records as Indicators of Current Entrainment Losses at Tampa Bay CWIS				
Chapter D	04: Value of Baseline I&E Losses from Four Facilities on Tampa Bay				
D4-1	Overview of Valuation Approach				
D4-2	Economic Value of Recreational Fishery Losses				
D4-3	Economic Value of Average Annual Commercial Fishery Losses Resulting from I&E at Big Bend				
D4-4	Indirect Use: Forage Fish				
D4-5	Nonuse Values				
D4-6	Summary of Economic Valuation of Mean Annual I&E at Big Bend				
D4-7	Summary of Annual Value of Baseline Economic Losses from I&E at Tampa Bay Facilities				
Chapter D	D5: RUM Analysis				
D5-1	Data Summary				
D5-2	Site Choice Model				
D5-3	Trip Participation Model				
D5-4	Welfare Estimates				
D5-5	Limitations and Uncertainty				
Chapter C	06: Benefits Analysis for Four Facilities on Tampa Bay				
D6-1	Overview of I&E and Associated Economic Losses				
D6-2	Economic Benefits of Reduced I&E of Selected Species at Four In-Scope Facilities on Tampa Bay				
D6-3	Summary of Omissions, Biases, and Uncertainties in the Benefits Analysis				

Chapter D7: Conclusions

Appendix D1: Life History Parameter Values Used to Evaluate I&E

Chapte	er E1: Background
E1-1	Overview of Case Study Facilities
E1-2	Environmental Setting
E1-3	Socioeconomic Characteristics
Chapte	er E2: Technical Description of Facilities
E2-1	Operational Profile
E2-2	CWIS Configuration and Water Withdrawal
Chapte	er E3: Evaluation of I&E Data
E3-1	Aquatic Species Vulnerable to I&E at the Pittsburg and Contra Costa Power Plants
E3-2	Life Histories of Species Impinged and Entrained at the Pittsburg and Contra Costa Plants
E3-3	Facility Methods for Estimating I&E
E3-4	Annual Impingement
E3-5	Annual Entrainment
E3-6	Summary: Combined Impacts of Pittsburg and Contra Costa
Chapte	r E4: Economic Value of I&E Losses Based on Benefits Transfer Techniques
E4-1	Overview of Valuation Approach
E4-2	Economic Value of Recreational Fishery Losses Resulting from I&E at Pittsburg and
	Contra Costa
E4-3	Nonuse Values
E4-4	Summary of Annual Value of Baseline Economic Losses at Pittsburg and Contra Costa
Chapte	r E5: Societal Revealed Preference Approach for Valuing Special Status Fish Species
E5-1	Valuing Special Status Species
E5-2	Habitat Restoration Costs
E5-3	Opportunity Costs of Water Use Foregone to Protect Special Status Species Fish
E5-4	Current Abundance and Restoration Targets
E5-5	Total Costs for Special Status Species Fish
E5-6	Conclusions
Chapte	er E6: Benefits Analysis
E6-1	Summary of Current I&E and Associated Economic Impacts
E6-2	Potential Economic Benefits due to Regulation
E6-3	Summary of Omissions, Biases, and Uncertainties in the Benefits Analysis

Chapter	E7: (Concl	usions
---------	-------	-------	--------

Appendix E1: Life History	Parameter	Values	Used	to	Evaluate I	&E
---------------------------	-----------	--------	------	----	------------	----

Appendix E2: Valuing Water Uses Foregone

Appendix E3: Presentation of Population Estimates

Chapter F1: Introduction

- F1-1 Overview of Case Study Facility
- F1-2 Environmental Setting
- F1-3 Socioeconomic Characteristics

Chapter F2: Technical Description of the Brayton Point Station

- F2-1 Operational Profile
- F2-2 CWIS Configuration and Water Withdrawal
- F2-3 Brayton Point Generation

Chapter F3: Evaluation of I&E Data

- F3-1 Species Impinged and Entrained at Brayton Point
- F3-2 Life Histories of Major Species Impinged and Entrained
- F3-3 Brayton Point Generating Station's I&E Sampling Methods
- F3-4 Annual Impingement and Entrainment
- F3-5 Summary

Chapter F4: Value of I&E Losses at the Brayton Point Station Based on Benefits Transfer Techniques

- F4-1 Overview of Valuation Approach
- F4-2 Economic Value of Average Annual Losses to Recreational Fisheries Resulting from I&E at Brayton Point Station
- F4-3 Economic Value of Average Annual Commercial Fishery Losses Resulting from I&E at Brayton Point Station
- F4-4 Economic Value of Forage Fish Losses
- F4-5 Nonuse Values
- F4-6 Summary of Mean Annual Economic Value of I&E at Brayton Point Station

Chapter F5: HRC Valuation of I&E Losses at Brayton Point Station

- F5-1 Step 1: Quantify I&E Losses
- F5-2 Step 2: Identify Habitat Requirements
- F5-3 Step 3: Identify Potential Habitat Restoration Alternatives to Offset I&E Losses
- F5-4 Step 4: Consolidate, Categorize, and Prioritize Identified Habitat Restoration Alternatives

F5-5	Step 5: Quantify the Expected Increases in Species Production for the Prioritized Habitat Restoration Alternatives
F5-6	Step 6: Scaling Preferred Restoration Alternatives
F5-7	Unit Costs
F5-8	Total Cost Estimation
F5-9	Conclusions
Chapte	r F6: Benefits Analysis for the Brayton Point Station
F6-1	Summary of Current I&E and Associated Economic Impacts
F6-2	Potential Economic Benefits due to Regulation
F6-3	Summary of Omissions, Biases, and Uncertainties in the Benefits Analysis
Chapte	r F7: Conclusions
Append	lix F1: Life History Parameter Values Used to Evaluate I&E
Chapte	r G1: Background
G1-1	Overview of Case Study Facilities
G1-2	Environmental Setting
G1-3	Socioeconomic Characteristics
Chapte	r G2: Technical and Economic Descriptions of the Seabrook and Pilgrim Facilities
G2-1	Operational Profile
G2-2	CWIS Configuration and Water Withdrawal
Chapte	r G3: Evaluation of I&E Data
G3-1	Aquatic Species Vulnerable to I&E at the Seabrook and Pilgrim Facilities
G3-2	Life Histories of Most Abundant Species in Seabrook and Pilgrim I&E Collections
G3-3	Seabrook's Methods for Estimating Impingement and Entrainment
G3-4	Seabrook's Annual Impingement and Entrainment
G3-5	Pilgrim's Methods for Estimating Impingement and Entrainment
G3-6	Pilgrim's Annual Impingement and Entrainment
G3-7	Summary and Comparison of I&E at Seabrook and Pilgrim
G3-8	Potential Biases and Uncertainties in I&E Estimates
Chapte	r G4: Value of I&E Losses at the Seabrook and Pilgrim Facilities Based on Benefits
Transfe	er Techniques
G4-1	Overview of Valuation Approach
G4-2	Economic Value of Average Annual Loses to Recreational Fisheries Resulting from I&E at Seabrook and Pilgrim Facilities
G4-3	Economic Value of Average Annual Commercial Fishery Losses Resulting from I&E at Seabrook and Pilgrim

G4-4	Economic Value of Forage Fish Losses				
G4-5	Nonuse Values				
G4-6	Summary of Mean Annual Economic Value of I&E at Seabrook and Pilgrim				
Chapter (95: HRC Valuation of I&E Losses at the Pilgrim Facility				
G5-1	Step 1: Quantify I&E Losses				
G5-2	Step 2: Identify Habitat Requirements				
G5-3	Step 3: Identify Potential Habitat Restoration Alternatives to Offset I&E Losses				
G5-4	Step 4: Consolidate, Categorize, and Prioritize Identified Habitat Restoration Alternatives				
G5-5	Step 5: Quantify the Expected Increases in Species Production for the Prioritized Habitat				
	Restoration Alternatives				
G5-6	Step 6: Scaling Preferred Restoration Alternatives				
G5-7	Unit Costs				
G5-8	Total Cost Estimation				
G5-9	Conclusions				
Chapter (66: Benefits Analysis for the Seabrook and Pilgrim Facilities				
G6-1	Overview of I&E and Associated Economic Values				
G6-2	Baseline Losses Using HRC Method				
G6-3	Anticipated Economic Benefits of Reduced I&E from Various Technologies				
G6-4	Summary of Omissions, Biases, and Uncertainties in the Benefits Analysis				
Chapter 6	97: Conclusions				
Appendix	G1: Life History Parameter Values Used to Evaluate I&E				
Chapter I	H1: Background				
H1-1	Overview of J.R. Whiting Facility				
H1-2	Environmental Setting				
H1-3	Socioeconomic Characteristics				
Chapter I	H2: Technical and Economic Descriptions of the J.R. Whiting Facility				
H2-1	Baseline Operational Characteristics				
H2-2	CWIS Configuration and Water Withdrawal				
Chapter I	H3: Evaluation of I&E Data				
H3-1	Species Vulnerable to I&E				
H3-2	Life Histories of Major Species Impinged and Entrained				
H3-3	J.R. Whiting's Methods for Estimating I&E				
H3-4	J.R. Whiting's Annual I&E Without the Net				

H3-5 H3-6	J.R. Whiting's Annual Impingement With the Ne Summary
Chapter	· H4: Economic Value of I&E Losses Based on Benefits Transfer Techniques
H4-1	Overview of Valuation Approach
H4-2	Value of Baseline Recreational Fishery Losses at J.R. Whiting Facility
H4-3	Baseline Economic Losses from Commercial Fishing
H4-4	Indirect Use: Forage Fish
H4-5	Nonuse Values
H4-6	Summary of Annual Value of Baseline Economic Losses at J.R. Whiting
Chapter	· H5: Streamlined HRC Valuation of I&E Losses at the J.R. Whiting Facility
H5-1	Quantify I&E Losses by Species (Step 1)
H5-2	Identify Species Habitat Requirements (Step 2), Identify Habitat Restoration Alternatives (Step 3), and Prioritize Restoration Alternatives (Step 4)
H5-3	Quantify the Benefits for the Prioritized Habitat Restoration Alternatives (Step 5)
H5-4	Scale the Habitat Restoration Alternatives to Offset I&E Losses (Step 6)
H5-5	Estimate "Unit Costs" for the Habitat Restoration Alternatives (Step 7)
H5-6	Develop Total Cost Estimates for I&E Losses (Step 8)
Chapter	· H6: Benefits Analysis for the J.R. Whiting Facility
H6-1	Summary of Figures of Baseline Losses
H6-2	Baseline Economic Losses
H6-3	Economic Benefits of Installing a Barrier Net
H6-4	Potential Economic Benefits due to Regulation
Chapter	· H7: Conclusions
Append	ix H1: Life History Parameter Values Used to Evaluate I&E
Chapter	r I1: Background
I1-1	Overview of Monroe Facility
I1-2	Environmental Setting
I1-3	Socioeconomic Characteristics
Chapter	· I2: Technical Description of Monroe
I2-1	Operational Profiles
I2-2	CWIS Configuration and Water Withdrawal

a l . •	
Chapter 13: Evaluation of I&E Data	
I3-1	Species Impinged and Entrained at Monroe
I3-2	Life Histories of Major Species Impinged and Entrained
I3-3	Methods for Estimating I&E at Monroe
I3-4	Annual Impingement and Entrainment
Chapter 14: Economic Value of 1&E Losses Based on Benefits Transfer Techniques	
I4-1	Overview of Valuation Approach
I4-2	Value of Baseline Recreational Fishery Losses at the Monroe Facility
I4-3	Value of Baseline Commercial Fishery Losses at the Monroe Facility
I4-5	Nonuse Values for Baseline Losses at the Monroe Facility
Chapter 15: Streamlined HRC Valuation of I&E Losses at the Monroe Facility	
I5-1	Quantify I&E Losses by Species (Step 1)
I5-2	Identify Species Habitat Requirements (Step 2), Identify Habitat Restoration Alternatives
	(Step 3), and Prioritize Restoration Alternatives
I5-3	Quantify the Benefits for the Prioritized Habitat Restoration Alternatives (Step 5)
I5-4	Scale the Habitat Restoration Alternatives to Offset I&E Losses (Step 6)
I5-5	Estimate "Unit Costs" for the Habitat Restoration Alternatives (Step 7)
I5-6	Develop Total Cost Estimates for I&E Losses
Chapter 16: Benefits Analysis for the Monroe Facility(Step 8)	
I6-1	Overview of I&E and Associated Losses
I6-2	Potential Economic Benefits due to Regulations
I6-3	Summary of Omissions, Biases, and Uncertainties in the Benefits Analysis
Chapter 17: Conclusions	
Appendix I1: Monroe Life History Parameter Values	
Glossary	

TOC xii

References